PROBLEMS

1. (a) 35°C: $254\text{ mm Hg} \times \frac{308\text{ K}}{330\text{ K}} = 237\text{ mm Hg}$ 45°C: $254\text{ mm Hg} \times \frac{318\text{ K}}{330\text{ K}} = 245\text{ mm Hg}$

   (b) 35°C: 237 mm Hg > vp CH_3OH 45°C: 245 mm Hg < vp CH_3OH

   (c) 35°C: 203 mm Hg 45°C: 245 mm Hg

   (d) 35°C: liquid, vapor 45°C: vapor

3. (a) $n = \frac{(0.300/760\text{ atm})(1.000\text{ L})}{(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(298\text{ K})} = 1.61 \times 10^{-5}\text{ mol}$

   mass = $(1.61 \times 10^{-5}\text{ mol})(128.2\text{ g/mol}) = 0.00207\text{ g} = 2.07\text{ mg}$

   (b) Assume all the naphthalene sublimes.

   $$P_{calc} = \frac{(7.00 \times 10^{-4}\text{ g}) \times (1\text{ mol}/128.2\text{ g}) \times (0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K}) \times (298\text{ K})}{1.000\text{ L}} = 1.34 \times 10^{-4}\text{ atm}$$

   $= 0.102$ mm Hg

   VP > P_{calc}; assumption is correct; P in the flask is 0.102 mm Hg. The flask contains only vapor.

   (c) Assume all the naphthalene sublimes.

   $$P_{calc} = \frac{(4.00 \times 10^{-3}\text{ g}) \times (1\text{ mol}/128.2\text{ g}) \times (0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K}) \times (298\text{ K})}{1.000\text{ L}} = 7.63 \times 10^{-4}\text{ atm}$$

   $= 0.580$ mm Hg

   VP < P_{calc}; assumption is wrong; P in the flask is 0.300 mm Hg. The flask contains solid and vapor.

5. (a) $n = \frac{(228/760\text{ atm}) \times (2.00\text{ L})}{(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K}) \times (298\text{ K})} = 0.0245\text{ mol}$; mass = 0.0245 mol × 159.8 g/mol = 3.92 g

   (b) Assume all the bromine in the flask is vapor.

   $$P_{calc} = \frac{(2.00\text{ g}) \times (1\text{ mol}/159.8\text{ g}) \times (0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K}) \times (298\text{ K})}{2.00\text{ L}} = 0.153\text{ atm} = 116\text{ mm Hg}$$

   VP > P_{calc}; assumption is correct; P in the flask is 116 mm Hg. The flask contains only vapor.

   (c) Assume all the bromine in the flask is vapor.

   $$P_{calc} = \frac{(2.00\text{ g}) \times (1\text{ mol}/159.8\text{ g}) \times (0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K}) \times (298\text{ K})}{0.750\text{ L}} = 0.408\text{ atm} = 310\text{ mm Hg}$$

   VP < P_{calc}; assumption is wrong; P in the flask is 228 mm Hg. The flask contains liquid and vapor.

7. (a) $\ln \frac{448}{197} = \frac{\Delta H}{8.31}\left[\frac{1}{296} - \frac{1}{318}\right]$; $\Delta H = 2.92 \times 10^4$ J = 29.2 kJ

(b) $\ln \frac{760}{197} = \frac{29200}{8.31}\left[\frac{1}{296} - \frac{1}{T}\right]$; T = 334 K = 61°C

9. $\ln \frac{760}{P} = \frac{40700}{8.31}\left[\frac{1}{350} - \frac{1}{373}\right]$; P = 321 mm Hg

11. (a) $\ln \frac{(1.75)(760)}{625} = \frac{40700}{8.31}\left[\frac{1}{367.6} - \frac{1}{T}\right]$; T = 390 K = 117°C

(b) 117°C – 94.5°C = 23°C

13. The graph is linear; slope = $\frac{y_2 - y_1}{x_2 - x_1} = \frac{-\Delta H_{vap}}{R}$

Use any two points on the y-axis and the corresponding x-axis:

$\frac{-\Delta H_{vap}}{R} = \frac{\ln 400 - \ln 10}{(1/377) - (1/299.2)}$ where R = 8.31 J/mol · K; ΔH_{vap} = 39.8 kJ

15. (a) solid (b) liquid (c) vapor

17. (a) A (b) supercritical fluid (c) no (d) F
(e) yes (f) no (g) no

19. (a) sublimes (b) melts (c) liquifies (d) liquifies

21. (a) Phase diagram similar to Figure 9.7 (a) with the triple point at 281 mm Hg on the y - axis and -121°C on the x - axis. A point on the vapor-liquid equilibrium curve should have 760 mm Hg on the y - axis and -108°C on the x - axis.

(b) ≈ 500 mm Hg (c) yes

23. (a) Phase diagram similar to Figure 9.7 (a) with the triple point at 20 mm Hg on the y - axis and 90°C on the x - axis. A point on the vapor-liquid equilibrium curve should have 760 mm Hg on the y - axis and 120°C on the x - axis.

(b) ≈ 120°C (c) liquid vaporizes

25. (a) > (d) > (c) > (b)

27. All show dispersion forces; (c) and (d) show dipole forces.

29. (a), (c), (d)

31. (a) stronger dispersion forces (b) stronger dispersion forces
(c) hydrogen bonding (d) ionic vs molecular

33. (b), (d)

35. (a) PCl_3; molecular vs ionic (b) AsH_3; no H bonds
(c) $C_2H_5OCH_3$; no H bonds (d) HCl; weaker dispersion forces

37. (a) dispersion forces (b) ionic bonds (c) dispersion forces (d) dispersion forces

39. (a) network covalent (b) molecular (c) ionic

41. (a) molecular (b) metallic (c) molecular

43. (a) metallic (b) ionic (c) molecular
(d) molecular (e) ionic

45. (a) C_{60}, $C_{12}H_{22}O_{11}$ (b) Na_2CO_3 (c) graphite (d) steel

47. (a) Na^+, I^- ions (b) N_2 molecules (c) K^+, O^{2-} ions (d) Au^+ ions, e^-

49. $s^3 = 0.0375\,nm^3$; $s = 0.335$ nm; $\frac{r}{s} = \frac{0.145}{0.335} = 0.433 = \frac{\sqrt{3}}{4}$; body-centered cubic

51. $s = \frac{4r}{\sqrt{2}} = \frac{4(0.181\text{ nm})}{1.414} = 0.512$ nm

53. (a) 0.513 nm − 0.362 nm = 0.151 nm
(b) no: ($2r = 0.190$ nm); no: ($2r = 0.266$ nm)

55. $s\sqrt{3} = 2(r\ Cs^+ + r\ Cl^-)$

57. (a) 4 (b) 8 for 4 Cl^- at the corners; 2 for Cl^- in center

59. % humidity = P_{H_2O}/P_{TOT}; P_{H_2O} = (0.38)(26.74) = 10.17 mm Hg

$$\text{mol water vapor at } 27^\circ\text{C} = \frac{(10.17/760\ \text{atm})(1.25\ \text{L})}{(0.0821\ \text{L}\cdot\text{atm/mol}\cdot\text{K})(300\ \text{K})} = 6.79 \times 10^{-4}\ \text{mol}$$

$$\text{mol water vapor at } 5^\circ\text{C} = \frac{(6.54/760\ \text{atm})(1.25\ \text{L})}{(0.0821\ \text{L}\cdot\text{atm/mol}\cdot\text{K})(278\ \text{K})} = 4.71 \times 10^{-4}\ \text{mol}$$

mol water condensed = $(6.79 \times 10^{-4}) - (4.71 \times 10^{-4}) = 2.08 \times 10^{-4}$ mol

mass water condensed = $(2.08 \times 10^{-4}$ mol)(18.02 g/mol) = 0.00374 g

61. (a) water vapor pressure before compression = water vapor pressure after compression = 23.76 mm Hg

The pressure can only change if the volume is increased.

(b) $$\text{moles of water before compression} = \frac{(23.76/760\ \text{atm})(5.25\ \text{L})}{(0.0821\ \text{L}\cdot\text{atm/mol}\cdot\text{K})(298\ \text{K})} = 0.00671\ \text{mol}$$

$$\text{moles of water after compression} = \frac{(23.76/760\ \text{atm})(2.00\ \text{L})}{(0.0821\ \text{L}\cdot\text{atm/mol}\cdot\text{K})(298\ \text{K})} = 0.00256\ \text{mol}$$

mass of water condensed = (0.00671 mol − 0.00256 mol)(18.02 g/mol) = 0.0749 g

63. $$V = (15 \times 12 \times 8.0)\ \text{ft}^3 \times \frac{28.32\ \text{L}}{1\ \text{ft}^3} = 4.1 \times 10^4\ \text{L}$$

$$n = \frac{(1.63 \times 10^{-3}/760\ \text{atm})(4.1 \times 10^4\ \text{L})}{(0.0821\ \text{L}\cdot\text{atm/mol}\cdot\text{K})(298\ \text{K})} = 3.6 \times 10^{-3}\ \text{mol}$$

$$\text{Volume of Hg}(l) = 3.6 \times 10^{-3}\ \text{mol} \times \frac{200.6\ \text{g}}{1\ \text{mol}} \times \frac{1\ \text{mL}}{13\ \text{g}} = 5.5 \times 10^{-2}\ \text{mL}$$

65. $$\ln \frac{760\ \text{mm Hg}}{37.0\ \text{mm Hg}} = \frac{\Delta H_{\text{vap}}}{0.00831\ \text{kJ/mol}\cdot\text{K}}\left(\frac{1}{293\ \text{K}} - \frac{1}{360\ \text{K}}\right); \quad \Delta H_{\text{vap}} = 39.5\ \text{kJ}$$

$$\ln \frac{P_2}{37.0\ \text{mm Hg}} = \frac{39.5\ \text{kJ}}{0.00831\ \text{kJ/mol}\cdot\text{K}}\left(\frac{1}{293\ \text{K}} - \frac{1}{298\ \text{K}}\right); \quad P_2 = 48.6\ \text{mm Hg}$$

$$\text{moles of } CH_3N_2H_3 \text{ in 1 L} = \frac{(48.6/760\ \text{atm})(1.00\ \text{L})}{(0.0821\ \text{L}\cdot\text{atm/mol}\cdot\text{K})(298\ \text{K})} = 0.00261\ \text{mol}$$

mass of $CH_3N_2H_3$ in 1 L = (0.00261 mol/L)(46.08 g/mol) = 0.120 g/L

67. (a) Ten water molecules at the bottom of the container.

(b) Ten water molecules spread out evenly through the container.

(c) Ten hydrogen molecules (small) and five oxygen molecules (larger)

69. (a) EQ (b) MI (depends on the amount of ether in the flask)

(c) GT (d) LT (e) GT

71. (a) strongly dependent on T (b) not true; dipole forces, hydrogen bonds

(c) true (d) only at critical P or below

73. A = iodine, B = iron sulfide, C = silver, D = graphite

75. $\ln \dfrac{760\,\text{mm Hg}}{110\,\text{mm Hg}} = \dfrac{\Delta H_{\text{vap}}}{0.00831\ \text{kJ/mol}\cdot\text{K}}\left(\dfrac{1}{298\,\text{K}} - \dfrac{1}{350\,\text{K}}\right)$; $\Delta H_{\text{vap}} = 32.2$ kJ/mol

20.0 L $\times$ (1000 mL/1L) $\times$ (1.59 g/mL) $\times$ (1 mol/153.8 g) = 206.8 mol

heat required = (206.8 mol)(32.2 kJ/mol) = 6.66×10^3 kJ

76. $V_{\text{molar}} = \dfrac{55.85\,\text{g}}{7.86\ \text{g/cm}^3} = 7.11\ \text{cm}^3$

$0.496\ \text{nm} = s\sqrt{3}$; $s = 0.286$ nm; $V_{\text{atom}} = \dfrac{(0.286\ \text{nm})^3}{2} = 1.17 \times 10^{-2}\ \text{nm}^3 = 1.17 \times 10^{-23}\ \text{cm}^3$

$N_{\text{A}} = \dfrac{7.11}{1.17 \times 10^{-23}} = 6.08 \times 10^{23}$

77. (a) 3.60 g water formed

mass of $H_2O(g) = \dfrac{(18.02\,\text{g/mol})(26.74/760\,\text{atm})(10.0\,\text{L})}{(0.0821\,\text{L}\cdot\text{atm/mol}\cdot\text{K})(300\,\text{K})} = 0.257$ g; liquid and vapor

(b) 26.7 mm Hg

(c) 2.80 g H_2 remains; $P_{H_2} = \dfrac{(2.80/2.016\ \text{mol})(0.0821\,\text{L}\cdot\text{atm/mol}\cdot\text{K})(300\,\text{K})}{10.0\,\text{L}} = 3.42$ atm

$P_{\text{Tot}} = 3.42\ \text{atm} + 0.04\ \text{atm} = 3.46\ \text{atm}$

78. $\ln \dfrac{760\text{ mm Hg}}{100.0\text{ mm Hg}} = \dfrac{\Delta H}{8.31\text{ J}}\left(\dfrac{1}{293.2\text{ K}} - \dfrac{1}{347.3\text{ K}}\right);\qquad \Delta H = 31.7\text{ kJ/mol}$

$39°F = 4°C = 277\text{ K}$

$\ln \dfrac{100.0\text{ mm Hg}}{P} = \dfrac{31700}{8.31\text{ J}}\left(\dfrac{1}{277\text{ K}} - \dfrac{1}{293\text{ K}}\right);\qquad P = 47\text{ mm Hg}$

$\text{mass of vapor} = \dfrac{(133.4\text{ g/mol})(47/760\text{ atm})(18 \times 28.32\text{ L})}{(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(277\text{ K})} = 1.8 \times 10^2\text{ g}$

$\text{original mass} = 0.500\text{ pt} \times \dfrac{1\text{ qt}}{2\text{ pt}} \times \dfrac{1\text{ L}}{1.057\text{ qt}} \times \dfrac{10^3\text{ cm}^3}{1\text{ L}} \times \dfrac{1.325\text{ g}}{1\text{ cm}^3} = 313\text{ g}$

$\%\text{ left} = \dfrac{133}{313} \times 100\,\% = 42\,\%$

79. $\dfrac{120\text{ lb}}{0.10\text{ in}^2} \times \dfrac{1\text{ atm}}{15\text{ lb/in}^2} = 80\text{ atm}$

80/134 = 0.60°C; but heat conduction is more likely, but see *Scientific American*, Feb. 2000, p. 50

80. $4\,r_{anion} = \sqrt{2}\,(2\,r_{anion} + 2\,r_{cation})\qquad \dfrac{2\,r_{cation}}{2\,r_{anion}} = \dfrac{4 - 2\sqrt{2}}{2\sqrt{2}} = \dfrac{4 - 2.828}{2.828} = 0.4144$

81. $P_{C_3H_8}$ is the vapor pressure pf propane, which decreases exponentially with T; P_{N_2} is the gas pressure, which decreases linearly with T.